Chapter 35
An Embedded Online Hydraulic Fluid CM and RUL-System for Industry 4.0 Manufacturing Machines

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ABSTRACT

Production machines and devices, especially those that operate continuously in multi-shift operation or are critical for the production process, must be equipped with an intelligent condition monitoring system for critical machine components. This is the only way to ensure high availability and prevent downtimes in critical phases of the production processes, affecting customer delivery times. This has become especially important in the context of the strategy Industry 4.0, wherein information technology, telecommunications, and manufacturing are united when the means of production are becoming more independent. This also applies to hydraulic fluid, an important component of most heavy machinery. The chapter presents the design and advantages to be achieved by the implementation of a comprehensive online condition monitoring (OCM) and remaining useful lifetime (RUL) system of built-in hydraulic fluid. The presented OCM-RUL system is designed conceptually for Industry 4.0 and focuses on the remote monitoring and self-diagnosis function of health condition for the fluid.

INTRODUCTION

Modern production systems require increases in productivity with the lowest possible production costs, which can only be realised by a high degree of automation. One of the more common drive systems found within automation and production processes are hydraulic systems, which are expected to operate

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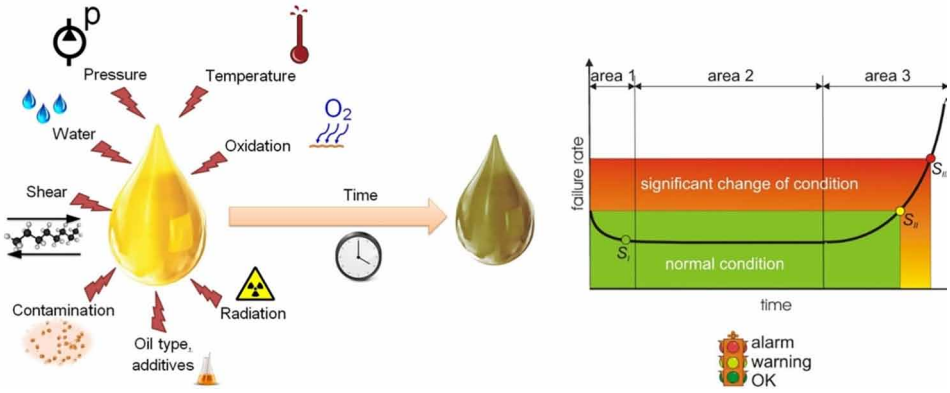
flawlessly throughout their service-lives. One of the more important components of the hydraulic system is, without doubt, the hydraulic fluid, since it influences the hydraulic system's operation directly. It has many roles, from transmitting forces and motion, to lubricating all tribological parts, to cooling the hydraulic system and preventing corrosion. Therefore, the hydraulic fluid and the hydraulic system itself must be maintained properly. Thus, the physical and chemical properties of the hydraulic fluid must remain within certain limits. However, because of fluid ageing and the influences of various operating conditions, the fluid properties change throughout its service-life.

Throughout its service-life the hydraulic fluid, e.g. the most commonly used hydraulic mineral based oil, is subject to many physical-chemical effects, which are visible as contamination of the fluid by solid particles, foreign fluids, or as fluid degradation because of the chemical reactions of ageing, as shown in Figure 1. The hydraulic fluid indirectly represents the condition of the hydraulic system itself, therefore its condition is of the utmost importance. If the hydraulic fluid`s condition is monitored continuously, the user's maintenance personnel can plan the maintenance interventions to guarantee the longest possible machine service-life and reliable system operation.

Figure 1. Influences on hydraulic fluid throughout its service-life (left) and typical service cycle (right)
(Data source: Tič V., Lovrec D., 2017; Meindorf T., 2011; Murrenhoff H., 2005)



Today, the hydraulic fluid's service-life is still usually determined on the basis of the machine maker's recommendations, i.e. specific fixed intervals, time period, or number of operating hours. In most cases, the time intervals are estimated from experience within a certain safety factor. Neither the actual hydraulic fluid condition (which may still be appropriate), nor the actual operating conditions of the machine (the workload of which may be lower than rated) are considered in this case. Therefore, the hydraulic fluid is often changed, although it still meets the prescribed requirements. In contrast, when the machine is overloaded, or in case of failure or even breakdown of any component occurring on the machine, premature or immediate deterioration of the physicochemical properties of the fluid occurs, which is certainly unplanned. Using the above mentioned oil monitoring strategies, they cannot be detectedwhen the machine is overloaded, or in the case when machine failure or component defect occurred, the premature, immediate and certainly unplanned deterioration of physical-chemical fluid properties occur, and in no case can it be detected.

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